Status of the Cryogenic Dark Matter Search

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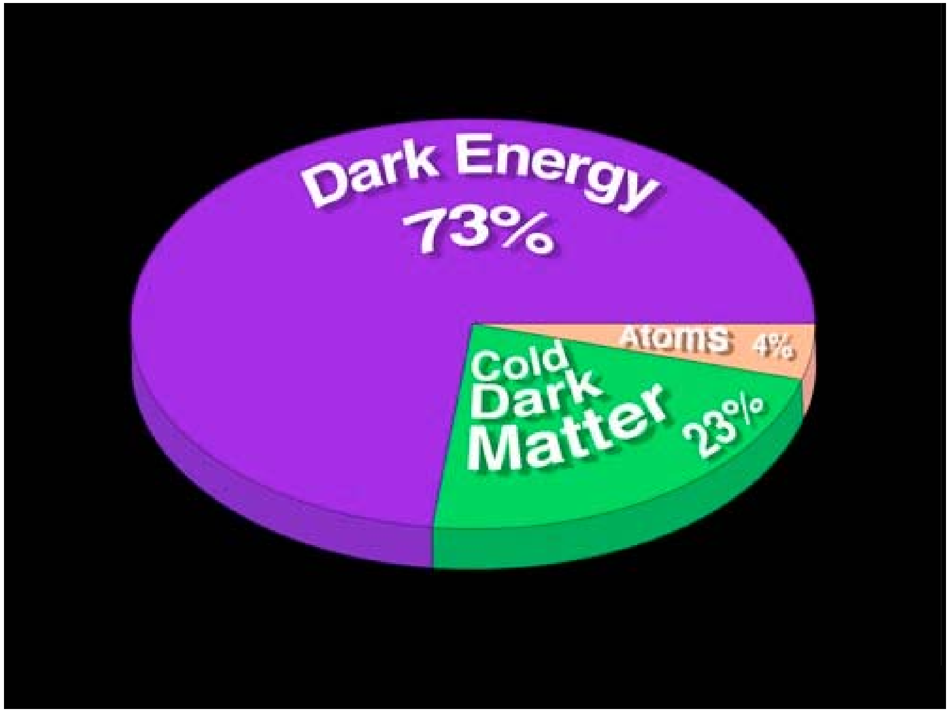
NIST, U Colorado Denver, Brown U, U Minnesota

The Universe, according to WMAP



What is the cold dark matter?

Convergence of cosmology

"cold" dark matter: density ~ 1/interaction rate

$\Rightarrow$weak-scale cross sections

and particle physics

Supersymmetry provides massive neutralino

$\Rightarrow$weak-scale cross sections

Weakly Interacting Massive Particles (WIMPs) may be dominant matter in the universe =>

WIMP wind from galactic dark matter halo

- WIMP velocities ~ 220 km/s
- local WIMP density ~ 0.3 GeV/cm^3
- WIMP-nucleon cross section ~ 10^{-42} cm^2

Technical difficulties for direct detection:

Expected event rates < 0.1 /keV/kg/day

- need large target mass, background rejection

Small energy deposition (≈ few keV)

- need low energy threshold

What is CDMS?

Dark Matter Search

Goal is direct detection of WIMPs which appear to hold our galaxy together

Cryogenic

Cool very pure Ge and Si crystals to < 50 mK using dilution refrigerator

Active Background Rejection

Detect heat and charge

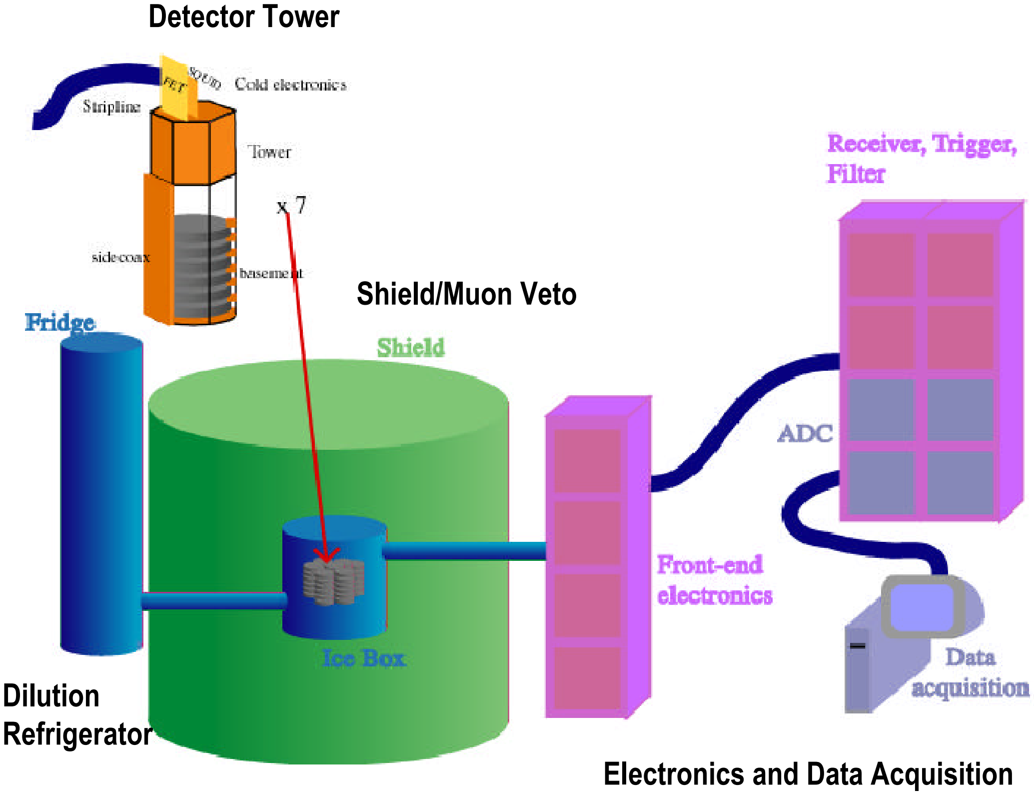
WIMPS, neutrons => nuclear recoils

Charge/Heat ~ 1/3

EM backgrounds => electron recoils

Charge/Heat = 1

Reject neutrons using multiple scattering and comparison of Ge to Si rates



Shielding

Layered shielding against radioactive backgrounds and active cosmic ray scintillator veto (>99.9% efficient).

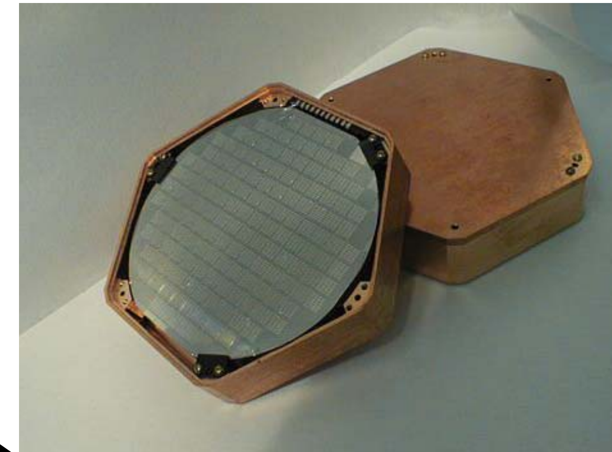
ZIP Detectors

Z-sensitive Ionization and Phonon Detectors

Low-voltage ionization measurement

Athermal phonon measurement

low-noise SQUID readout



Measured background rejection:

> 99.9% for EM backgrounds using charge/heat

> 98% for β's using pulse risetime as well

Better than expected in CDMS II proposal!

Tower of 6 ZIPs

Tower 1

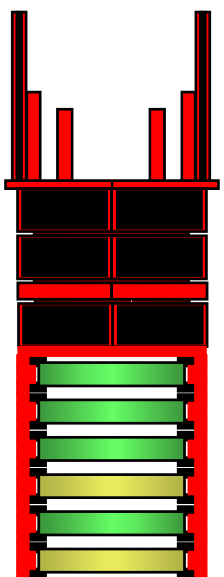
4 Ge

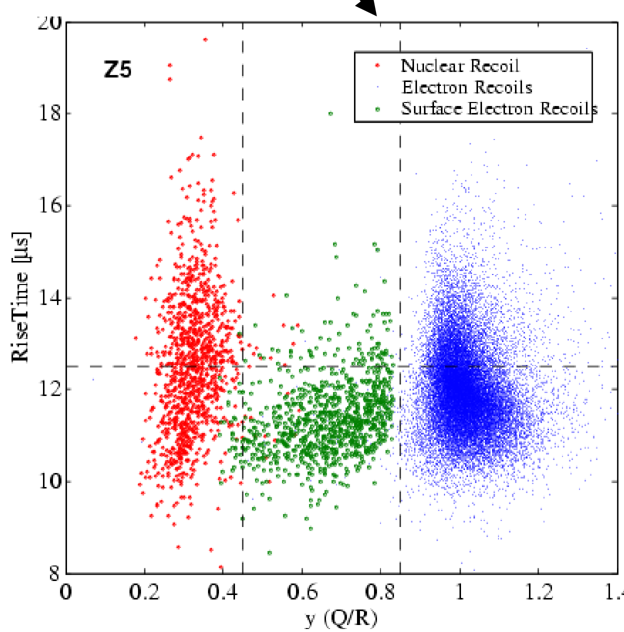
2 Si

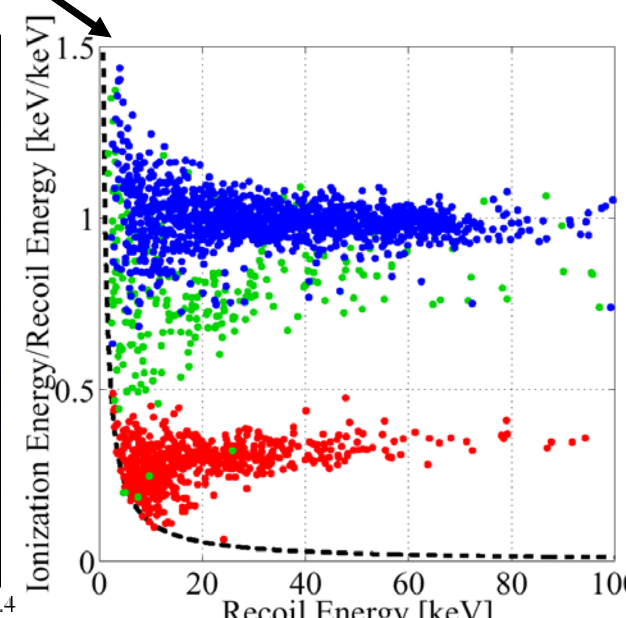
Tower 2

2 Ge

4 Si







CDMS at Stanford

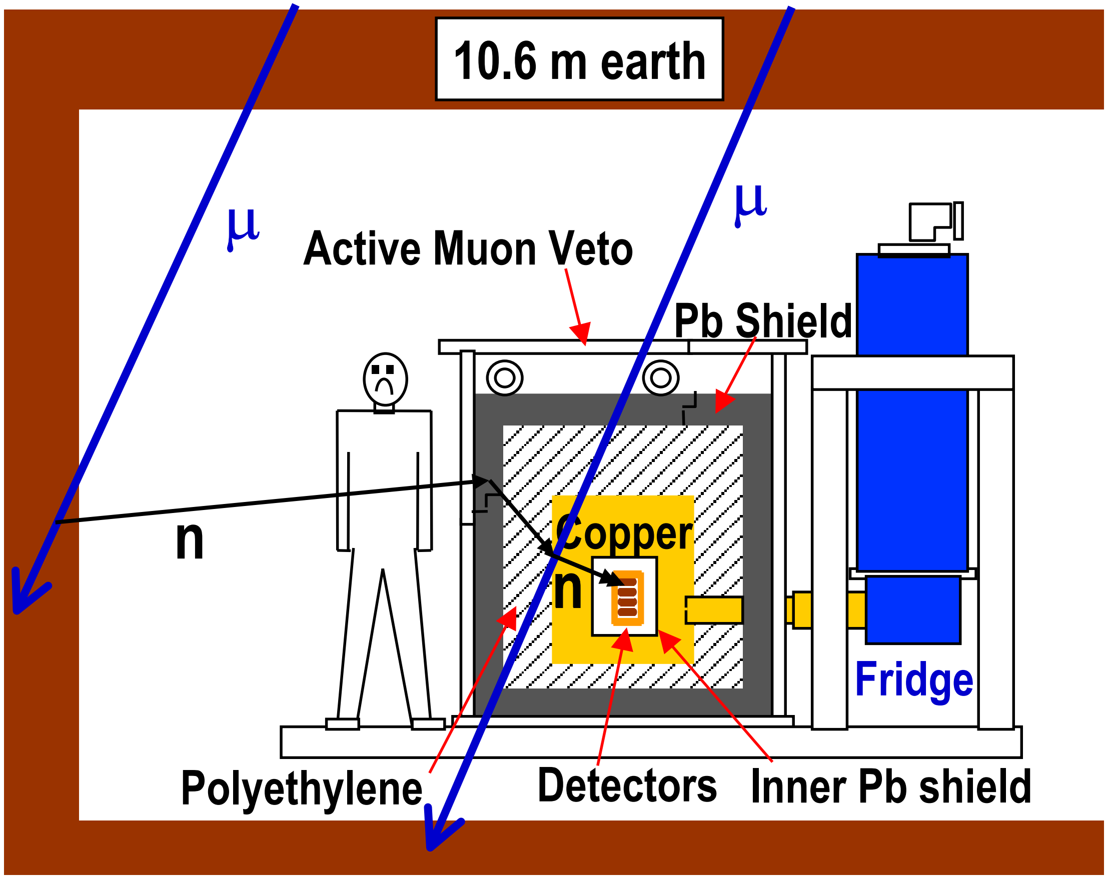
Shielded, low-background environment

Shallow (17 mwe) site

- Hadronic cosmic-ray flux reduced by >1000x
- Muons reduced by ~5x

Active muon veto

- >99.9% efficient
- Reject ~100 neutrons per kg-day produced by muons within shield

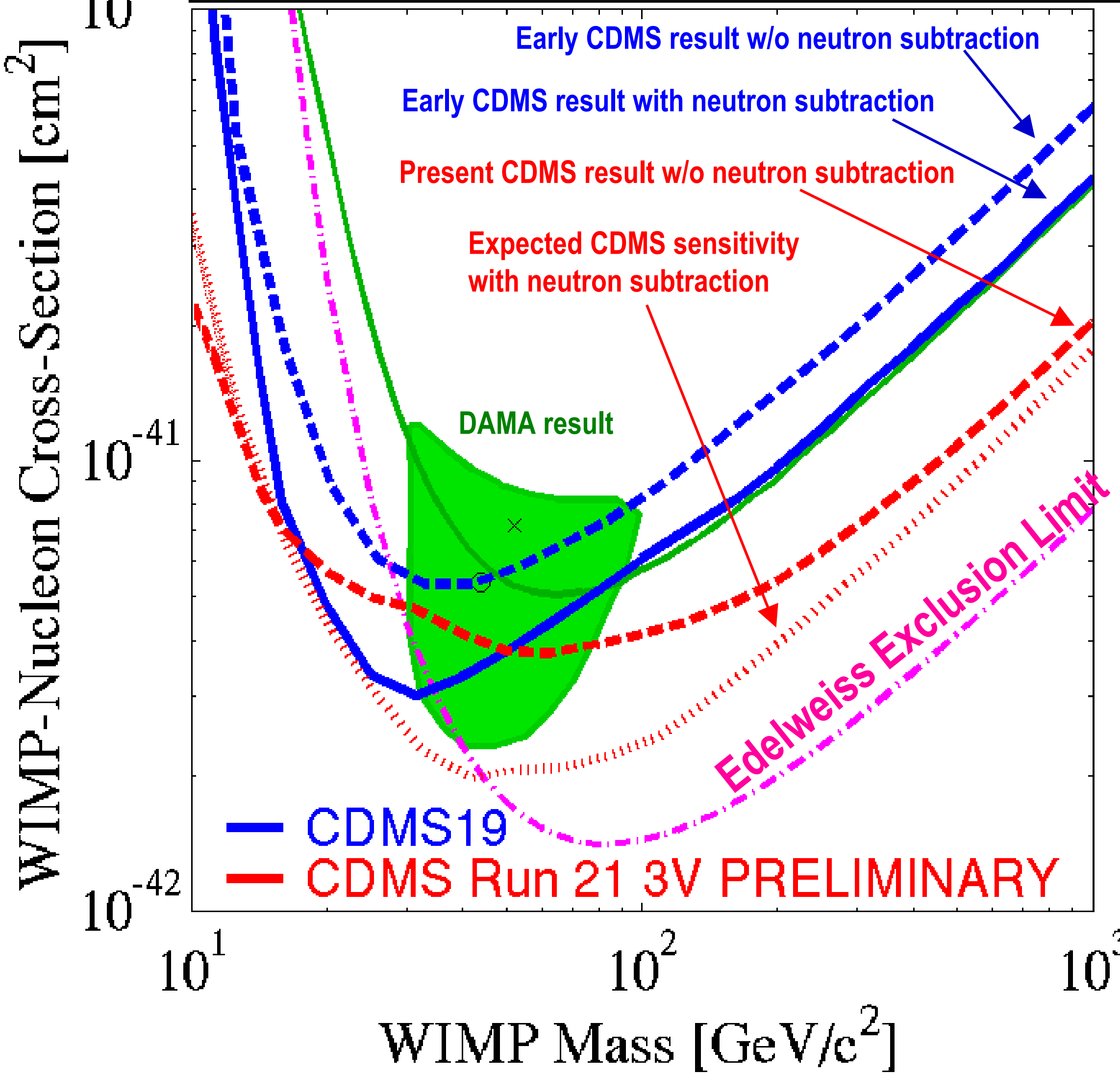


Expect neutron background ~2 / kg / day produced outside shield; measure using

- Si slightly more sensitive to neutrons, Ge x5 more sensitive to WIMPs
- Multiple-detector scatters must be neutrons, not WIMPs

CDMS 2001-2002 Data Run at Stanford

R. Abusaidi *et al.*, Phys. Rev. Lett. 84, 5699 (2000).
D.Abrams *et al.*, to appear in Phys. Rev. D (2002) astro-ph/0203500 v3



DAMA signal essentially excluded
For standard halo and
spin-independent interactions

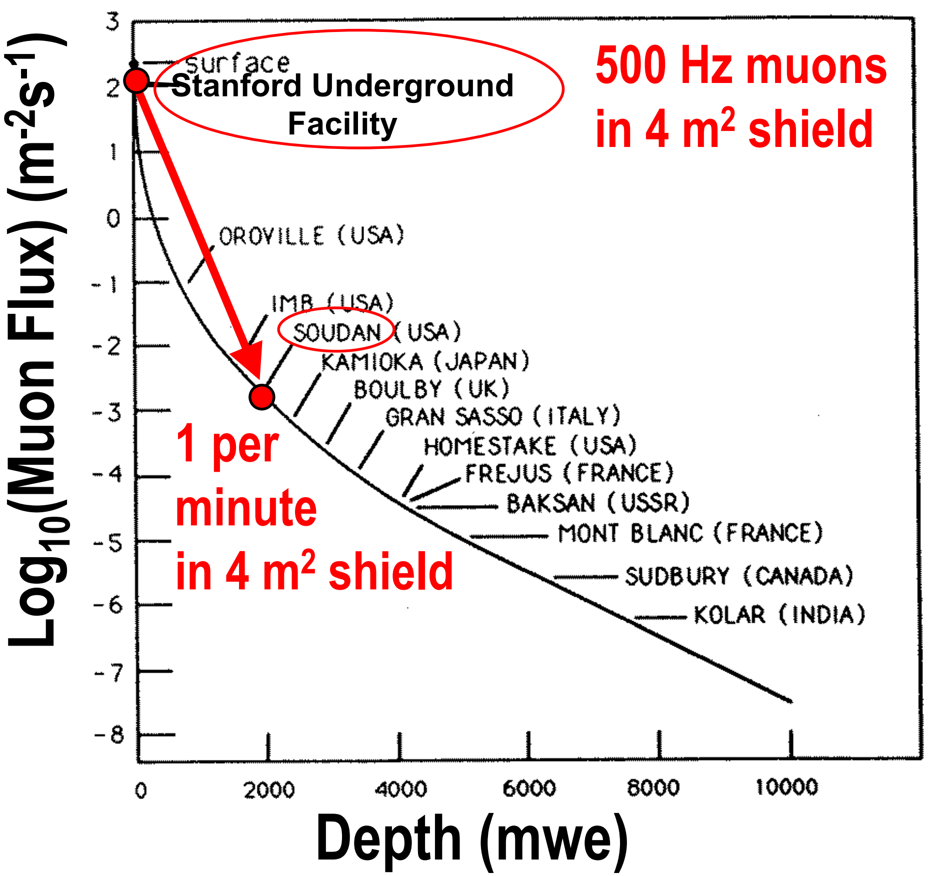
Edelweiss at deep site
Higher energy threshold
Worse limits at low mass
No neutron background
Better limits at high mass

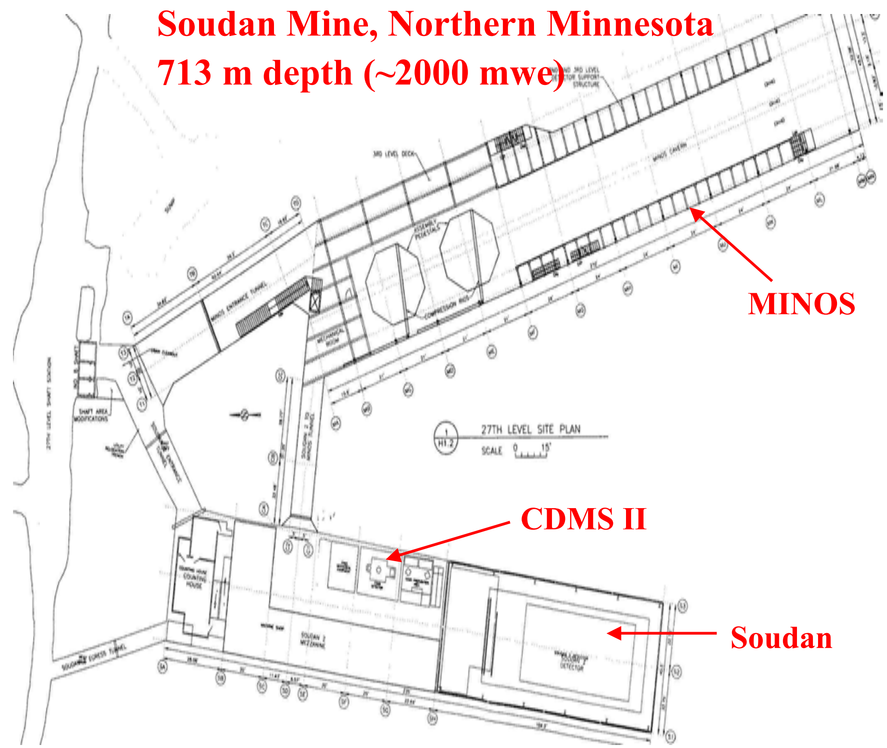
Priority for CDMS-II to “go deep”

CDMS II at Soudan

Depth of 2000 mwe reduces neutron background from
~1 / kg / day to ~1 / kg / year

Expect WIMP sensitivity of 0.01 / kg / kev /day





Dan Bauer, March 2003

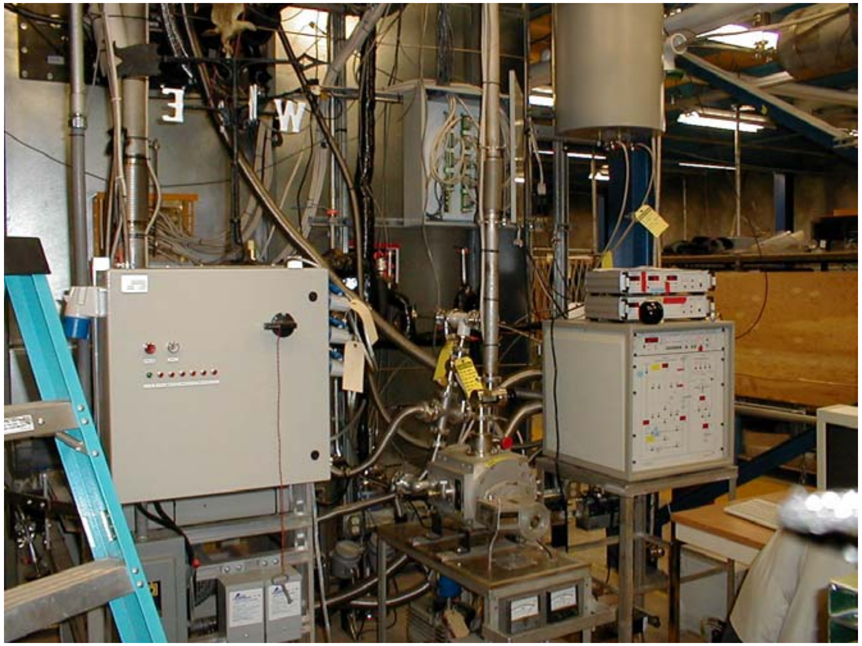
CDMS II Cryogenics at Soudan

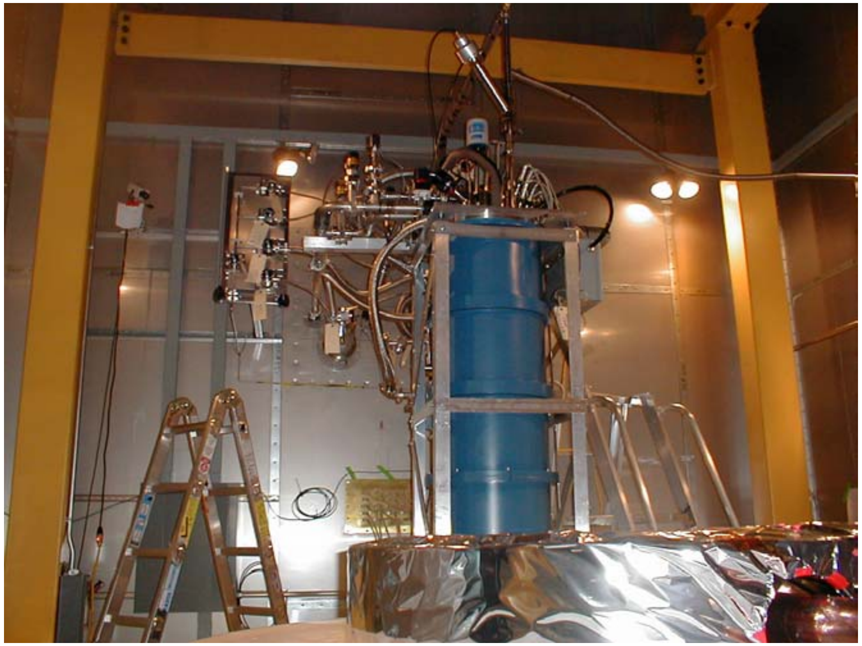
Serious problems with dilution refrigerator => 1 year delay

Problems now resolved (intense effort within collaboration)

Dilution refrigerator and icebox (detector cold volume) coupled

Cooled to 25 mK for 1 week in December, 2002





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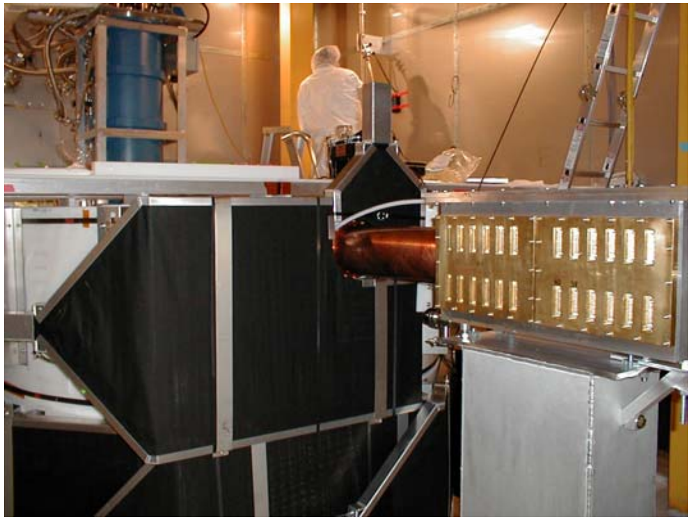
CDMS II Installation at Soudan

Shielding, DAQ, and Electronics nearly finished
System testing underway



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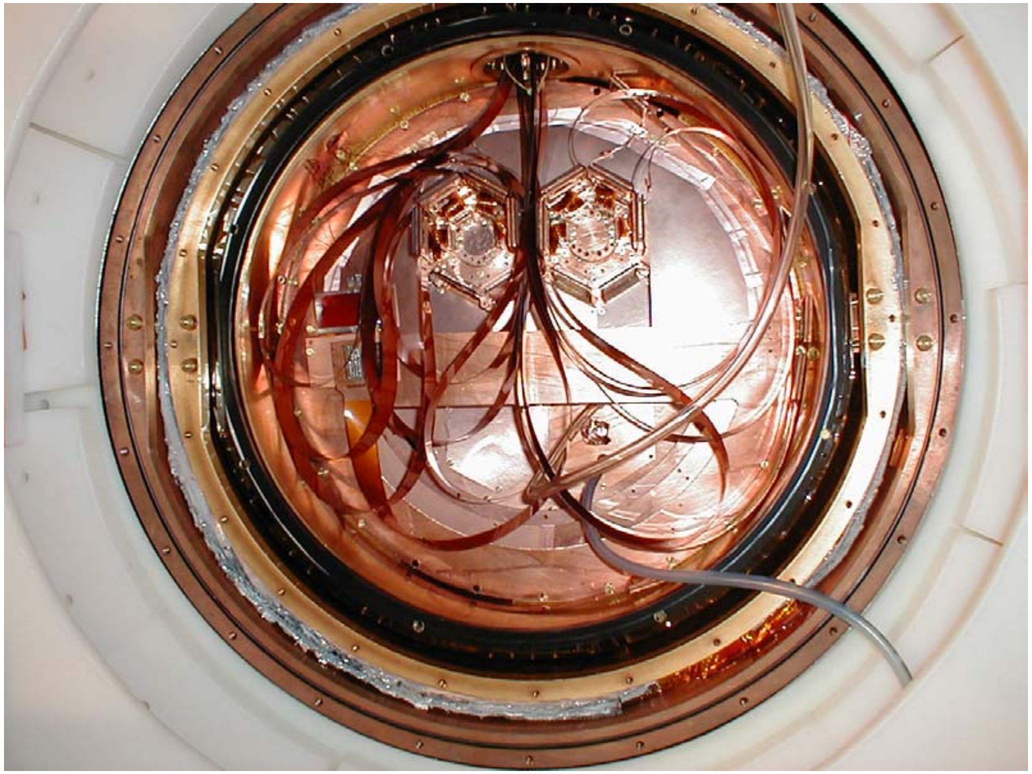
Detector Installation at Soudan

Two towers of Ge/Si detectors just installed
Warm checkout for next two weeks; then cooldown
First “dark” in April, 2003; commissioning/calibration
First “low-background” data in June, 2003



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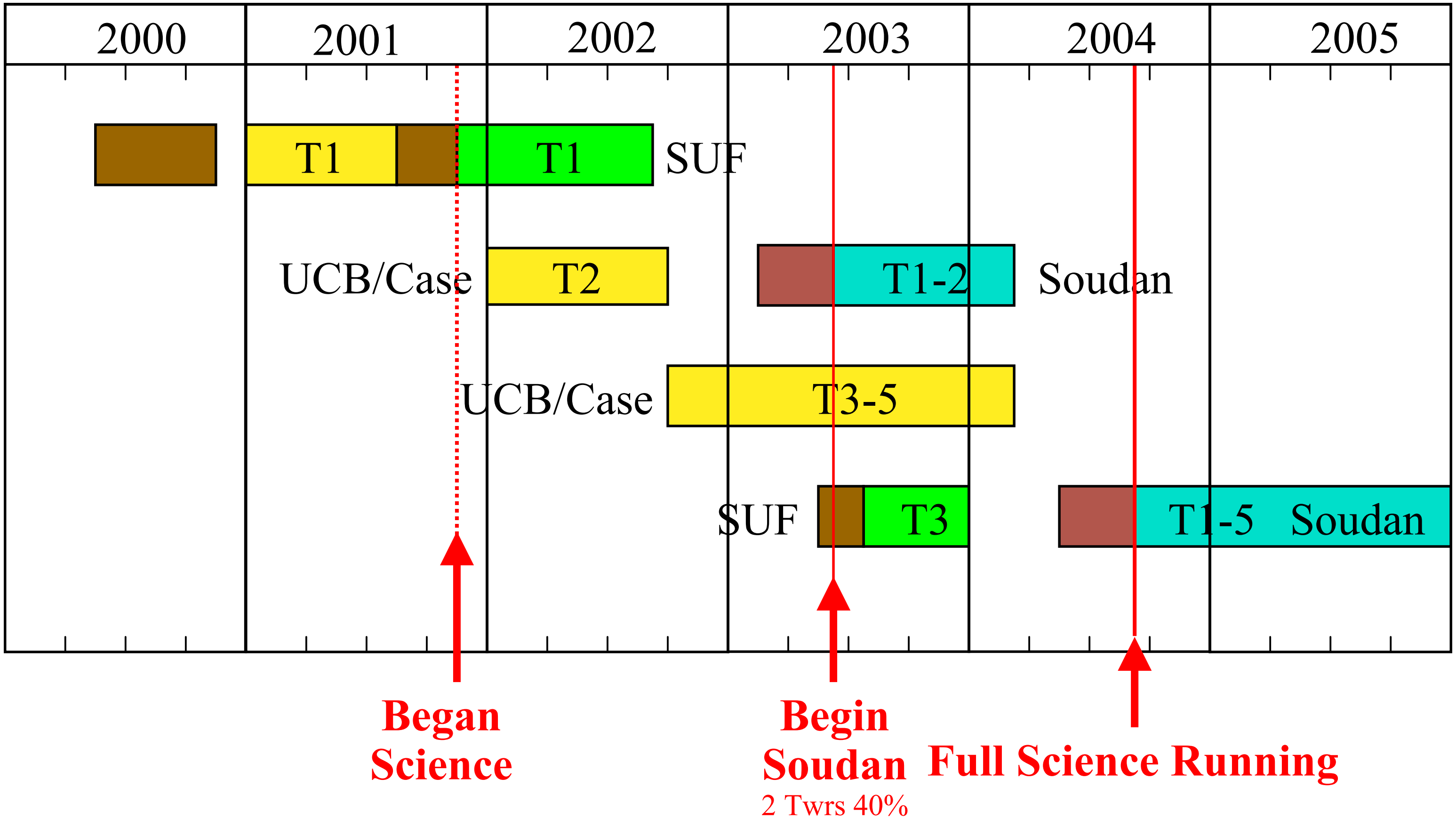
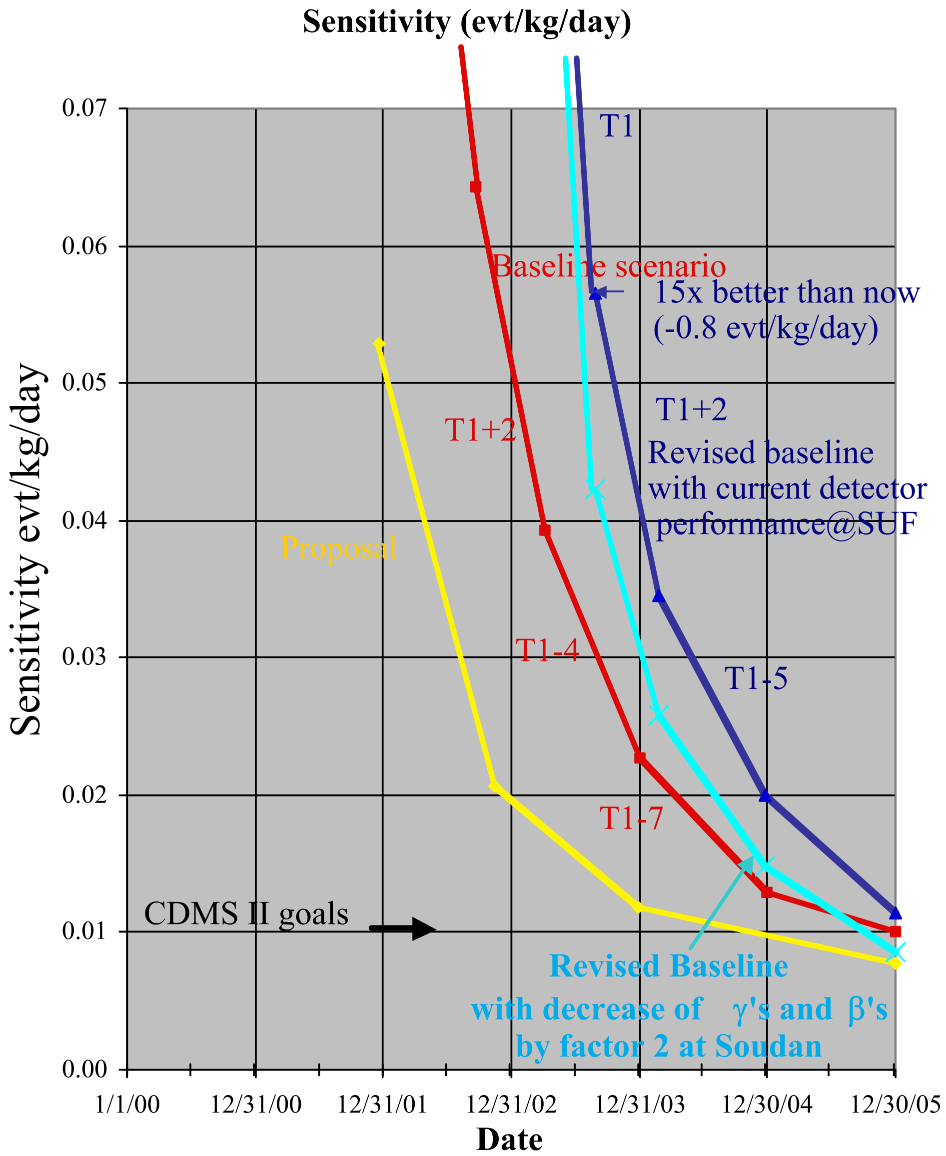
CDMS-II Schedule



This plan achieves science goals for original proposal. We plan to submit proposal to complete Towers 6-8 as follow-on with improved science reach.

CDMS II Expected Sensitivity



1 year delay: cryogenic problems

Dilution refrigerator, icebox now working

Experiment nearly ready at Soudan

System testing underway.

First detector deployment in Feb 2003

Tower 1: 4 Ge, 2 Si; Tower 2: 2 Ge, 4 Si

Ge more sensitive to WIMPs; Si needed to determine if signal due to neutrons.

Deep site => Much lower neutron background => Rapid improvement in sensitivity

Expect factor of 10 improvement over CDMS I results by end of 2003.

Deploy remainder of detectors in 2004 and run until end of 2005 (or longer)

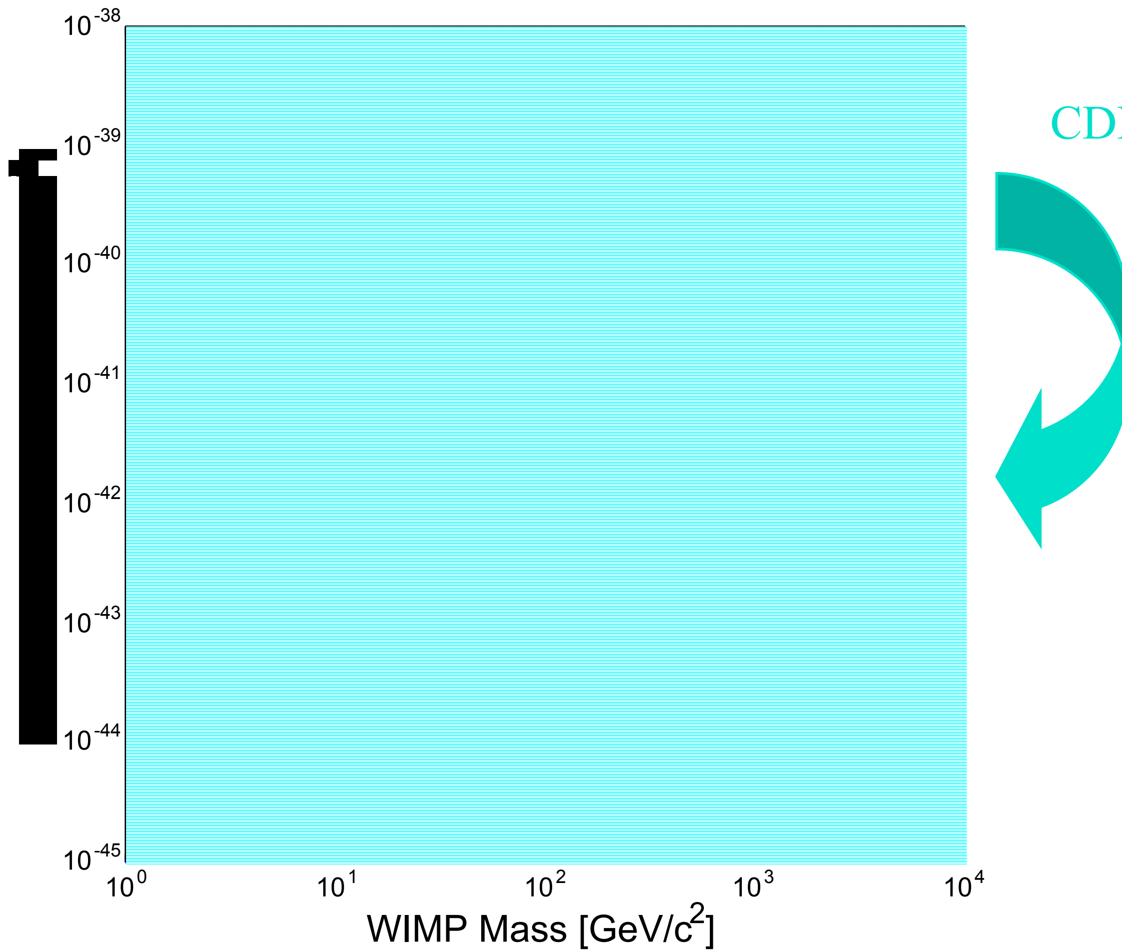
Detector performance improvements mean we should still reach original CDMS II goals (cyan curve)

CDMS II Reach

New CDMS result from Stanford site (thin blue curve)
Best WIMP limits at low mass

CDMS II should begin taking data by Summer 2003
Expect x10 improvement in limits by end of 2003 (or maybe hint of a signal?)

No other running experiment will make such rapid progress
Power of active background rejection.



CDMS II